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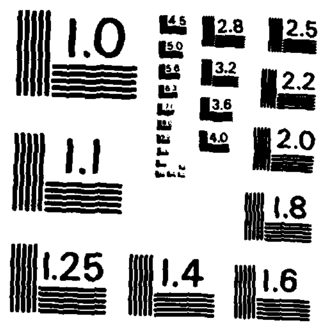

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The purpose of this three-year research program was to study electron transport in III-V semiconductors, starting with an investigation of ballistic transport in GaAs. Also for experimental studies of electron transport in the III-V semiconductors, test devices were to be constructed from submicron layers grown by molecular beam epitaxy. For ballistic electron transport in submicron GaAs devices, the influence of the boundary conditions were explained, a theory for low-field diode conductance was developed, the high-field diode impedance was

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ABSTRACT (cont).

calculated, and experimental data was compared to theoretical predictions. This work led to an investigation, both experimental and theoretical, of electron transport in the two-dimensional electron gas (TEG) of a modulation-doped heterostructure. The theoretical studies produced a model of electron transport in GaAs/AlGaAs modulation-doped structures and prediction of the electron mobility in TEG layers. The experimental work led to a new method of III-V heterojunction characterization and to an explanation of the temperature-dependent behavior of a modulation-doped transistor.

Final Report

ELECTRON BALLISTIC EFFECTS IN III-V SEMICONDUCTORS

Principal Investigators:

Gary Y. Robinson
Michael Shur

9/25/80 to 9/24/83

U. S. Army Research Office
Contract DAAG29-80-K-0087
Proposal DRXRO-17683-EL

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Statement of Problem Studied

The purpose of this three-year research program was to study electron transport in III-V semiconductors, starting with an investigation of ballistic (collision-less) transport in GaAs. Also for experimental studies of electron transport in the III-V semiconductors, test devices were to be constructed from submicron layers grown by molecular beam epitaxy (MBE).

For ballistic electron transport in submicron GaAs devices, the influence of the boundary conditions were explained, a theory for low-field diode conductance was developed, the high-field diode impedance was calculated, and experimental data was compared to theoretical predictions.

This work led to an investigation, both experimental and theoretical, of electron transport in the two-dimensional electron gas (TEG) of a modulation-doped heterostructure. The theoretical studies produced a model of electron transport in GaAs/AlGaAs modulation-doped structures and prediction of the electron mobility in TEG layers. The experimental work led to a new method of III-V heterojunction characterization and to an explanation of the temperature-dependent behavior of a modulation-doped transistor.

The research program was successful in explaining transport in certain, commercially important, III-V device structures and provided a new method of semiconductor materials qualification.

Summary of Results

The major accomplishments of the research program sponsored by ARO are as follows:

- Developed a theory of low-field conductance and high-field impedance in submicron structures [1,7].

- Developed a new analytical model for short-channel GaAs FETs [7].

- Performed experimental study and provided theoretical explanation of temperature dependence of threshold voltage in modulation-doped FETs [8].

- Developed a modified DLTS technique for study of traps in modulation-doped structures [10].

- Developed a theory for modulation doped structures which included the calculation of the maximum concentration n_{so} of the electrons in the two-dimensional electron gas (TEG) [4], the establishment of the relationship between the maximum transconductance and n_{so} [3], a computer and analytical calculation of the channel conductance as a function of the gate voltage [5], computer and analytical calculations of the I-V characteristics [6], an approximate calculation of the C-V characteristics [8], a detailed analysis of the undoped spacer layer [30], a calculation of the low field mobility of the TEG and an analysis of the maximum current swing [5,13,14].

- Joint research with Professor Hadis Morkoc (University of Illinois) led to joint publication of highest FET transconductance yet reported (565 mS/mm at 77K) [2].

- 18 papers published or submitted for publication; 13 conference presentations.

- Nine graduate students supported with two PhD degrees and three MS degrees awarded.

Publications

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4. A. A. Kastalsky and M. Shur, "Conductance of Small Semiconductor Devices," Conference on Microwave Semiconductor Devices and Circuits, Cornell Univ., August 1981.

5. Kwyro Lee and M. S. Shur, "Impedance of Thin Semiconductor Films in Low Electric Fields," Workshop on Compound Semiconductors (1982).

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